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Table of Contents

A- Introduction

In 2009, the Cambodian Ministry of Industry, Mines and Energy (MIME) approached the French Embassy in Phnom Penh for support in capacity building on rural electrification planning. A work plan was discussed with Innovation Energie Développement (IED), comprising 3 components:

1. Elaboration of Sustainable Rural Electrification Plans, using the GEOSIM tool (www.geosim.fr) for different fund availability options, combining national grid expansion and mini grid options, as well as stand alone options. These results are presented in this report;

2. Training of a team of MIME staff on the use of GEOSIM and transfer of the tool and methods to the Ministry, with a hands on approach;

3. Feasibility studies for 3 to 5 renewable energy based mini grids and exploring the possibility of mobilising investors for actual construction of the mini grids, in private public partnership approach.

Subsequently, a Memorandum of Understanding (MoU) was signed between MIME and IED on 29th January 2010. This report and the attached summary focus on the results of the first component, in the form of country and province level rural electrification plans.

B- Policy objectives and planning scenarii

The study was launched in a context of extremely ambitious political targets wherein the current policy objectives are:

- **By 2020, all villages should have be electrified**. Electrified is defined here as a village where more than 50% of households receive some form of electricity supply, including from batteries with access to a battery charging system;
- **By 2030, 70% of rural households should be connected to grid quality service** (24-hour mini-grids or national grid) at acceptable tariff level and with minimum subsidy from the government.

A recent document prepared by EAC has added new targets, which supplement the previous ones, while being slightly more ambitious:

- By **2020**, **80% of villages** should be electrified by the **national grid**, and the remaining 20% should be electrified by **mini-grids**
- By **2030**, **95% of villages** should be electrified by the **national grid**

In order to meet the above policy objectives, three scenarii have been defined. The three scenarii differ only by the rate at which the national grid will expand (Step 1), while the next steps follow the same approach.

Step 1 : national grid extension

- **Baseline scenario**: consistent with EDC plans for 2015, 2020 and 2030, and recent targets set by EAC, in terms of number of villages electrified by the national grid (cf. above)
- **Intermediate scenario**: same as baseline scenario but half as fast as in the baseline scenario (the same targets are reached, but taking twice the time compared to baseline scenario)
- **Conservative scenario**: one quarter as fast as the baseline scenario

Step 2 : mini-grid projects

Least-cost comparison of **mini hydro, biomass** (rice husk gasification, rice husk cogeneration or sugarcane bagasse cogeneration), and **diesel mini-grid projects** (with possible **PV hybridisation**), **to supply all "Development Poles"** (socio-economic growth centres) **not electrified by the national grid by 2015**.

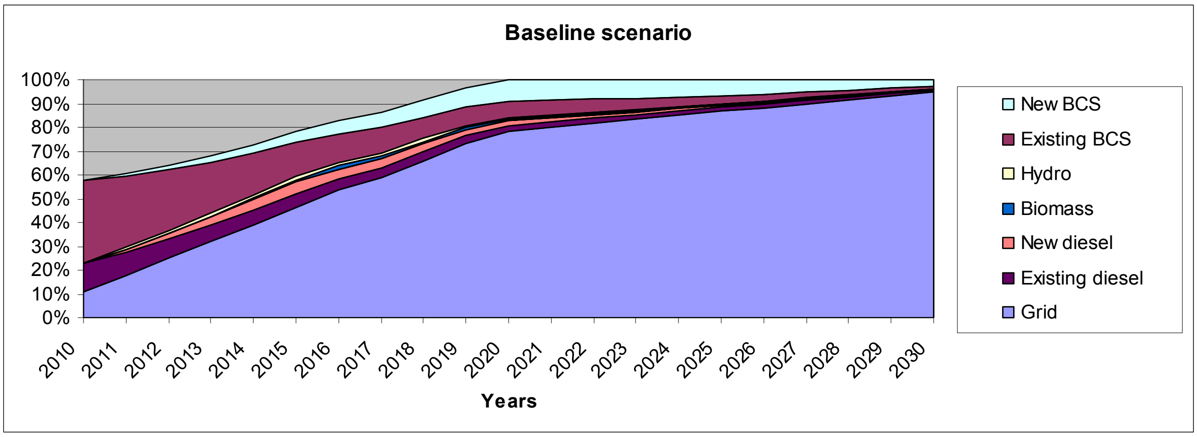
Step 3 : stand-alone systems

In order to reach the government village electrification targets by 2020, **Solar Battery Charging stations** and **Photovoltaic (PV) services for community facilities** have been suggested. Although not mandatory to reach policy targets, the depth of the market for **Solar Home Systems** (PV systems for individual) has been assessed as well.

The three suggested scenarii are in line with the policy objective of 100% grid quality villages by 2020, i.e. all villages would be electrified by either national grid, mini-grids or stand-alone systems. However, the second main policy objective for 2030 (70% households being connected to national grid or mini-grids) is reached only in the baseline scenario, but the two others come relatively close to it. Finally, the recent new objectives set by EAC and EDC for grid connected villages (80% by 2020 and 95% by 2030) are met only in the baseline scenario, while the two other scenarii are slightly less optimistic by definition.

C- Key planning results for the baseline scenario

The results of the baseline scenario in terms of percentage of villages electrified by the different suggested technologies is shown below:



The national grid, initially limited, quickly becomes the main rural electrification option, which means that about **4,400 new villages** would have to be connected to the grid and more than **7,000 km of MV lines** would have to be added by **2015** !

This of course now raises the question as to whether the required funds will be available to reach the grid objectives and whether it will be physically possible. Indeed, the investment requirements amount to:

- By 2015:
    - **143 MUSD** for Medium Voltage (MV), which will essentially have to be EDC borrowings or RGC allocations, as private operators (REEs) can contribute but only marginally to the effort
    - **184 MUSD** for distribution. It does not seem likely that REEs alone would be able to mobilise these funds, so the question of developing a financing mechanism to support REE borrowings is essential (soft loans) - and the Rural Electrification Fund (REF) could definitely be an option. EDC currently is not willing to borrow but only to implement grants allocated
    - **72 MUSD** for mini grids (and an additional **21 MUSD** if diesel projects include a PV component). At present, there is no public mechanism to finance this, as the REF has put this on hold. It seems very ambitious to imagine that the private sector could mobilise this amount in the coming 5 years. Besides, longer term issues such as integration with the national grid as Independent Power Producers (IPPs) once the national grid arrives, still need to be resolved
    - **19 MUSD** will have to be mobilised for stand alone (essentially PV) options during this first period
    - Therefore, **more than 400 MUSD worth of rural electrification investments** have to be executed during the coming 5 years, in order to meet the RGC targets

- Over the 20 year period to 2030, the targets are no less ambitious, with about **1 BIUSD** having to be mobilised to reach the political targets, the detailed breakdown of which is provided in the following table

Investment costs in rural areas (MUSD, constant price)	2011-2015	2016-2020	2021-2030
Sub-transmission network (MV lines)	143.4	118.2	83.3
Distribution (transformers, LV, meters)	184.0	158.7	203.5
Subtotal grid extension	**327.4**	**276.9**	**286.8**
Hydro mini-grid	31.5	0.9	0.2
Biomass mini-grid	16.4	0.6	0.2
New diesel mini-grid	23.9	2.4	0.4
Subtotal mini-grid projects	**71.8**	**3.8**	**0.8**
Solar home systems	6.7	8.3	0.0
Community PV	2.2	2.2	0.0
Solar battery charging stations	10.4	10.6	0.0
Subtotal stand-alone systems	**19.3**	**21.0**	**0.0**
Total	**418.4**	**301.8**	**287.6**

These investments allow us to reach the following coverage rates in terms of electrified village and connected households:

Coverage for rural areas		2010	2015	2020	2030
Connected households	National grid	6.9%	29.1%	47.4%	66.2%
	Hydro mini-grid	0.0%	0.6%	0.3%	0.1%
	Biomass mini-grid	0.0%	0.4%	0.3%	0.0%
	Existing diesel mini-grid	4.4%	1.9%	1.4%	0.6%
	New diesel mini-grid	0.0%	1.9%	1.2%	0.1%
	Solar home systems	0.0%	0.7%	1.4%	0.2%
	Total percentage of rural households	**11%**	**34%**	**52%**	**67%**
Electrified villages	National grid	10.9%	46.1%	78.3%	94.8%
	Hydro mini-grid	0.0%	1.5%	0.6%	0.2%
	Biomass mini-grid	0.0%	1.2%	0.7%	0.1%
	Existing diesel mini-grid	11.9%	5.4%	2.7%	0.9%
	New diesel mini-grid	0.0%	5.1%	1.9%	0.1%
	Existing battery charging stations	34.7%	14.3%	6.8%	1.3%
	Solar battery charging stations	0.0%	4.5%	9.0%	2.6%
	Total percentage of rural villages	**57%**	**78%**	**100%**	**100%**

The resulting investment costs and levelized cost of kWh for each technology are presented below:

		No villages[1]	000 HH	Invest (MUSD)	Inv. cost/ village ('000 USD)	Inv. cost /HH (USD)	kWh cost (USDc)
	Grid	10 572	1 838	891	84.3	485	21.0
Mini-grids	Hydro	193	15	33	168.8	2 244	26.3
	Biomass	157	9	17	109.0	1 853	24.2
	Diesel	643	47	27	41.5	565	38.4
Stand-alone	Solar BCS	1 138	131	20.9	18.4	160	36.3
	Community PV	1 994	-	4.4	2.2	-	-
	SHS	-	37	15,0	-	400	39.7

[1] The number of villages and households served by all technologies is higher than the total number of villages and households in Cambodia, as some villages and households may very well start being connected to a mini-grid or stand-alone project, and become connected to the national grid later on.

Investment costs per village for different technologies are interesting to compare: though the fact that the investment cost of a “hydro” village is about double that of a “grid” village may seem worrying at the outset, it is not at all so, as for grid villages, this is the average cost, and the hydro options typically are for the remoter locations, which are at the tail end of the grid and with a much higher marginal cost. As for biomass, even though they are usually located much closer to the national grid, and do have slightly higher investment costs per village, the long term kWh cost proves to be rather on par with the grid because of low O&M costs. All off grid options compare favourably to diesel (at +/- 38 UScts/kWh) and it must be born in mind that a scenario of explosion of fossil fuel prices has not been simulated.

Interesting to analyse is also the cost per household, which remains high for off grid options as unfortunately those remote villages tend to be little populated.

D- Spatial distribution of suggested rural electrification technologies

Highly populated provinces such as Kampong Cham, Battambang, Prey Veng and Siem Reap naturally require the highest total investment costs. Kampong Thom is an exception to this rule, with relatively high investment costs for all technologies and a low population

Grid expansion efforts are highest in the provinces around the existing main systems, i.e. Phnom Penh system (Kandal, Takeo, Prey Veng, Kampot) and the Western System (Banteay Meanchey, Battambang, Siem Reap). Pursat and Kampong Thom also enjoy significant investments in backbone infrastructure, being located between these two large systems due to be interconnected. Kampong Speu and most North-Eastern provinces (Otdar Meanchey, Preah Vihear, Stung Treng, Ratanak Kiri and Mondul Kiri) are also supposed to build very long MV lines, but our simulations tend to show that these provinces are not likely to be among the short term priorities (by 2015), if a least-cost approach is chosen, as opposed to plain political will. After a first phase of backbone infrastructure extension planned by EDC until 2020, one may expect the 2021-2030 phase to see more densification of the network (connection of villages close to the existing lines) as shown on the following map.

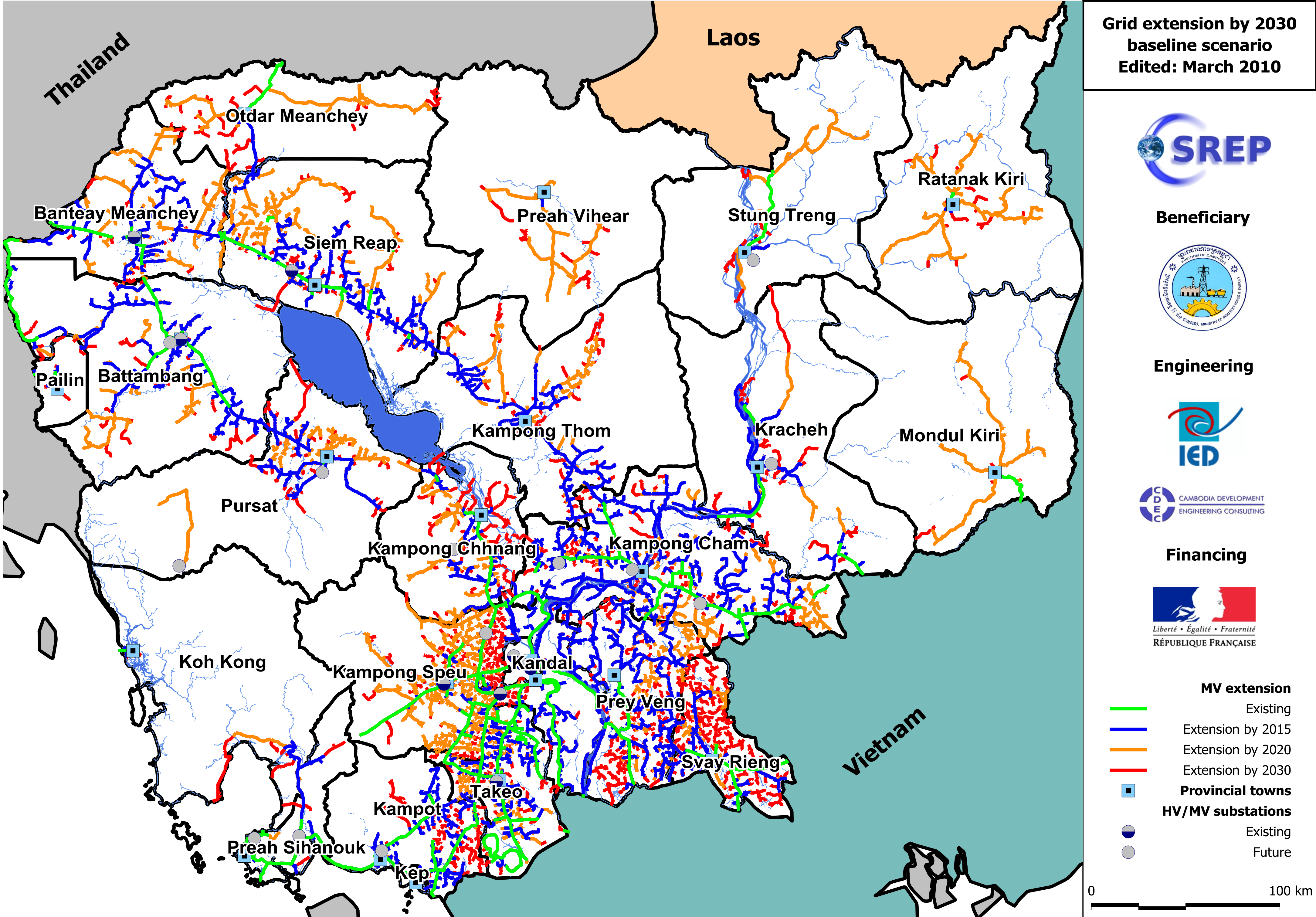
Hydro potential investments focus on the North-Eastern province (Rattanak Kiri, Mondul Kiri, Stung Treng), while the theoretical technical potential in the West and South-Western part (Battambang, Pursat, Kampot, Koh Kong), is kept in check by the quick development of the national grid and the low local demand near the identified potential sites.

Biomass investments are naturally higher where large cogeneration projects have been identified, e.g. Battambang, Otdar Meanchey, Stung Treng, Kandal and Koh Kong. These large projects tend to distort the actual representation in terms of number of projects, which would give the preference to North-Western provinces around the Tonle Sap lake (Battambang, Banteay Meanchey, Siem Reap).

Most proposed diesel projects are logically in provinces where grid investment are relatively modest, and/or thought to be less profitable in the short term (e.g. Kampong Speu, Svay Rieng, Kampong Chhnang). But a closer look at maps reveals that they are never really far from the planned MV lines, therefore attention will need to be paid to this risk factor for potential investors, especially if hybridisation with PV is sought.

Finally, investments in stand-alone systems is unexpectedly higher in provinces with decent national grid coverage (existing and planned), such as Svay Rieng, Prey Veng, Kampong Cham, Kandal and Kampot. On the other hand, remote provinces such as Mondul Kiri, Rattanak Kiri or Koh Kong are not in the top provinces in terms of stand-alone systems. The main reason for this is the population factor, and the fact that even in province with very high levels of national grid coverage, many villages, although located “under the lines”, may still remain unelectrified until 2020.

More details on the local characteristics of each province are available in the provincial rural electrification plans, covering all provinces in Cambodia, except Phnom Penh.



Grid extension by 2030
baseline scenario
Edited: March 2010
SREP
Beneficiary
Engineering
IED
CAMBODIA DEVELOPMENT ENGINEERING CONSULTING
Financing
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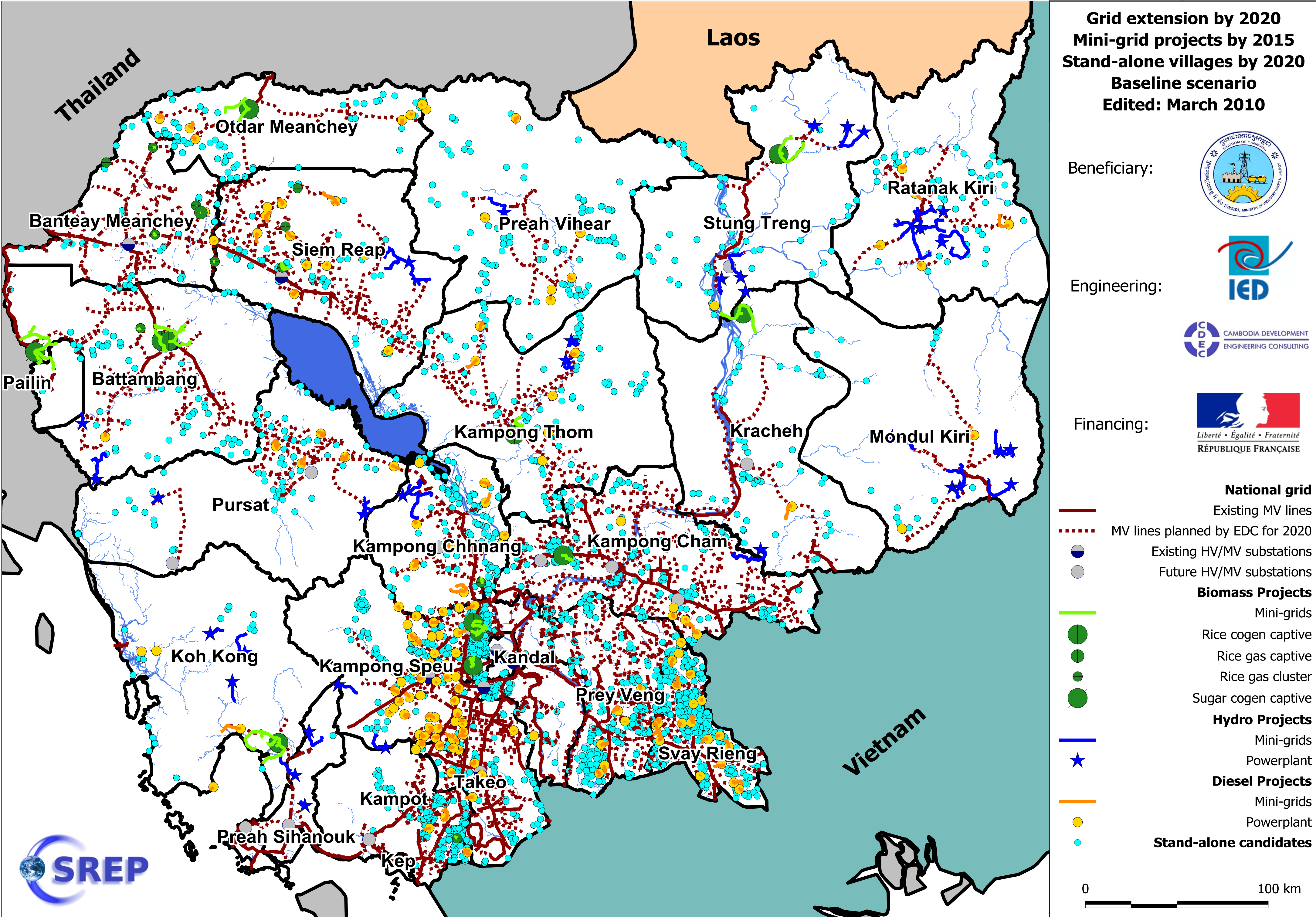
MV extension
Existing
Extension by 2015
Extension by 2020
Extension by 2030
Provincial towns
HV/MV substations
Existing
Future
0
100 km
Thailand
Laos
Vietnam
Otdar Meanchey
Banteay Meanchey
Siem Reap
Preah Vihear
Stung Treng
Ratanak Kiri
Pailin
Battambang
Kampong Thom
Kracheh
Mondul Kiri
Pursat
Kampong Chhnang
Kampong Cham
Koh Kong
Kampong Speu
Kandal
Prey Veng
Svay Rieng
Takeo
Kampot
Preah Sihanouk
Kep



Grid extension by 2020
Mini-grid projects by 2015
Stand-alone villages by 2020
Baseline scenario
Edited: March 2010
Beneficiary:
Engineering:
IED
CAMBODIA DEVELOPMENT ENGINEERING CONSULTING
Financing:
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National grid
Existing MV lines
MV lines planned by EDC for 2020
Existing HV/MV substations
Future HV/MV substations
Biomass Projects
Mini-grids
Rice cogen captive
Rice gas captive
Rice gas cluster
Sugar cogen captive
Hydro Projects
Mini-grids
Powerplant
Diesel Projects
Mini-grids
Powerplant
Stand-alone candidates
0
100 km
Thailand
Laos
Vietnam
Otdar Meanchey
Banteay Meanchey
Siem Reap
Preah Vihear
Stung Treng
Ratanak Kiri
Pailin
Battambang
Kampong Thom
Kracheh
Mondul Kiri
Pursat
Kampong Chhnang
Kampong Cham
Koh Kong
Kampong Speu
Kandal
Prey Veng
Svay Rieng
Takeo
Kampot
Preah Sihanouk
Kep
SREP

E- Detailed remarks for mini-grid and stand-alone projects

Given the optimistic grid extension assumptions, the share of mini-grid projects is very small in the baseline scenario, as most Development Poles are connected to the national grid by 2015. Moreover, this share decreases after 2015, as the grid extends further and thus interconnects with mini-grid projects.

This small market for mini-grid projects faces another issue: proximity with the national grid. On average, suggested projects are located about 20 km from the existing national grid, and 10km from the planned grid by 2015. While this proximity is a challenge for isolated mini-grid projects, it actually represents an advantage for IPP projects, i.e. projects aiming at injecting power directly into the national grid and which can compete with its bulk generation cost, provided a suitable regulatory framework is available. This is the case for some biomass and hydro projects.

Nonetheless, it will definitely remain a challenge to mobilise the required investments and carry out implementation of

- 208 mini grids projects electrifying about 1000 villages over the next 5 years
- Solar battery charging stations in about as many villages over the next 10 years
- 2000 odd community PV systems to be installed over the next 10 years

Mini-grid projects in rural areas by 2015	Number of projects	Total Installed capacity (MW)
Hydro mini-grid	33	6.4
Biomass mini-grid	25	10.3
New diesel mini-grid	150	21.7
Total	**208**	**38.4**

Investment costs in rural areas (MUSD)	2011-2015	2016-2020	2021-2030
Hydro mini-grid	31.5	0.9	0.2
Biomass mini-grid	16.4	0.6	0.2
New diesel mini-grid	23.9	2.4	0.4
Total mini-grid projects	**71.8**	**3.8**	**0.8**

Stand-alone systems	2011-2015	2016-2020	2021-2030
Solar home systems (new kits)	16 744	20 679	0
Community PV (new villages)	997	997	0
Solar battery charging stations (new villages)	569	455	0

Investment costs in rural areas ('000 USD)	2011-2015	2016-2020	2021-2030
Solar home systems	6.7	8.3	0
Community PV	2.2	2.2	0
Solar battery charging stations	10.4	10.6	0
Total stand-alone systems	**19.3**	**21.0**	**0**

Regarding mini-hydro projects, most potential sites are located in mountainous areas (mostly mountains in the Cardamoms Range and North-Eastern provinces), where there is little or no population, so they would probably be more suited to IPP and grid injection approaches, wherever the national grid is not too far and can absorb the power. However, given that a number of large hydro projects are being constructed and commissioned, it is doubtful that it would make any sense to develop such small hydro IPPs. In conclusion, there is very little mini hydro potential making economic sense for mini grids – where population is located. Smaller systems than the ones we studied (less than 50kW) may still offer some interest in mountainous regions, but this would be more considered as

stand-alone systems rather than grid-quality electricity, considering issues with seasonality and overall reliability of these pico turbines.

For biomass mini-grid projects, three routes have been explored: biogas, cogeneration and gasification.

- To date, there are very few large agro-industries in the country having the quantity of humid waste required for biogas. There are only about 5 pig farms and about as many cassava starch factories, which could be potentials for such units in the medium term.
- Cogeneration (combined production of heat and power) again requires fairly large units, which also need the heat. Until recently, relevant agro-industries (large rice mills, sugar production) were not large enough to offer such opportunities. However, a few (5 to 10) such investments are being prepared in Cambodia. We have assumed that these multi megawatt deals would provide 500kW to 2MW for local mini grid electrification, the rest being used for own consumption or selling to the grid.
- Smaller scale gasifiers offer more short term potential, and SME Cambodia has been selling and installing gasifiers which have a fairly good track record. The rice mills typically consumes only 30% of the husk for own consumption and hence the balance could be used to sell to the local REE, which runs on diesel. However, agro-industries being usually located in areas already electrified by the grid (or soon to be electrified), these projects usually offer only short term opportunities for off-grid electrification, unless the regulatory framework evolves to allow easier injection of power on the national grid for such small-scale projects (which may prove competitive).
- **The overall situation of the agro-industry sector and thus opportunities for biomass projects is expected to evolve very quickly over the next few years in Cambodia**, as new policies aim to foster a modern, high added value and export based industry. Therefore the above conclusions might have to be revised significantly after a few years, depending on the effectiveness of such changes.

Considering limitations in hydro and biomass projects, new diesel mini-grid projects had to be designed, in order to supply all the remaining villages identified as “Development Poles” or “growth centres”, and which require grid-quality service by 2015. As seen in the above table, the **number of diesel projects actually exceeds largely the number of projects for other mini-grid technologies**.

All simulations have been performed assuming that these new projects would be indeed purely diesel based, although using slightly more modern and efficient equipments. However, international experience now shows that with the dropping of PV panel prices and the increase in reliability of technology, the PV production cost, with financing available over 15 years, could be between 20 and 70 UScents/kWh:

- The lowest range being for large units feeding into the grid without any battery storage
- Mid range being for smaller capacities and feeding into a diesel grid typically, with a small share of battery storage, the PV power being produced during the day, stored and then consumed in the night time
- The most costly being for very small units and with up to 100% battery storage

Unfortunately, most new diesel mini-grid projects proposed under the rural electrification plan belong to the second or third category. Therefore, the costs are expected to be slightly high, but still competitive with current diesel generation costs under most circumstances. The additional PV capacity and related investment costs required to hybridise these new projects, totalling **21 MUSD**, are detailed below:

Capacity range (kW)	Proposed solution	Baseline		
		Number of projects	PV installed capacity (kWp)	Investment cost (MUSD)
<30	100% storage	7	37	0.2
30-100	50% storage	43	523	2.9
>100	0% storage	100	3 773	17.8
	Total	**150**	**4 333**	**21.0**

Please note that under the current conditions, it is not obvious that all projects above 100 kW would allow PV hybridisation with a 20% penetration rate and no storage, as suggested here. This will need to be studied on a case by case basis and will depend on the presence of daytime productive uses such as telecommunication antennas. However, it can be expected that in the longer term, given the depth of the market of diesel operators, increase in fuel prices and further cost reduction of PV at the global stage, even projects currently comparing unfavourably with diesel may eventually become suitable for PV.

As for stand-alone systems, the depth of the market looks rather significant, even under the most optimistic grid extension scenario, with 2,000 community PV to be installed, as well as solar battery charging stations in more than 1,100 villages, and a potential for 37,000 individual Solar Home Systems to be installed by 2020.

F- Sensitivity analysis: intermediate and conservative scenarii

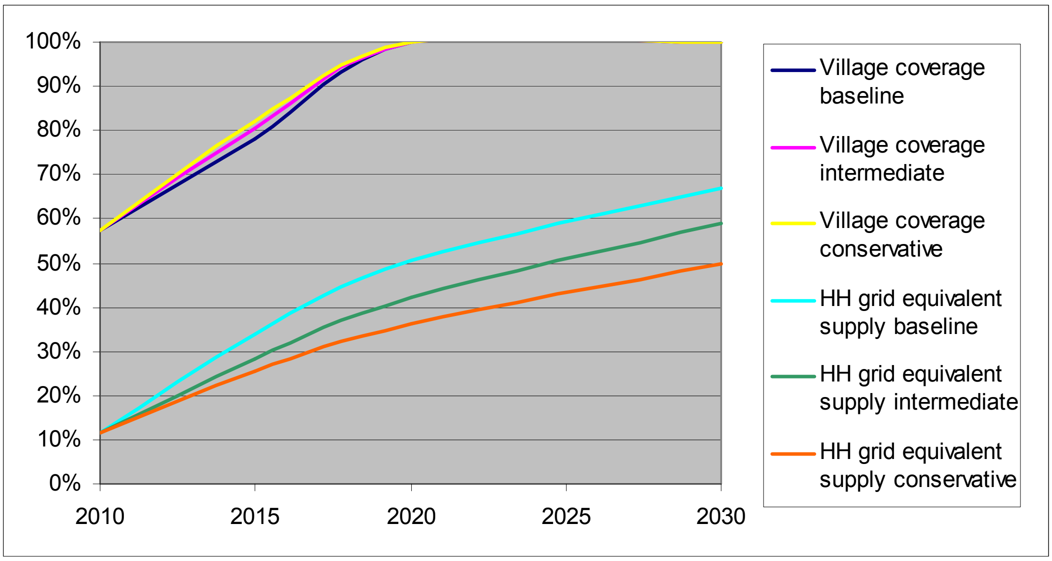
Overall, the ultimate target of electrifying 100% of the villages are met in all three scenarios. However, the target of 70% households is met in the baseline scenario only, while the two others come slightly lower.

Reaching the 70% target in the conservative scenario is a difficult undertaking, because this would mean many more mini-grid projects would be needed in villages which are not Development Poles, i.e. with low socio-economic potential and thus very low expected profitabilities. Besides, as explained above, most of these projects would happen very close, or even under the planned national grid, which is usually a serious issue for any sensible project developer. Another solution to reach the 70% target in the intermediate and conservative scenarios, would be to increase the connection rate inside already electrified villages, but this would require direct subsidies as the remaining 30% of households in rural villages are usually located far from the village centre and/or have very low capability to pay.

As illustrated in the following graph, the contrast between the three scenarios also lies in the speed at which the targets are met, looking objectively into the difficulty of mobilising the funds as required in the baseline scenario.

The global investment costs until 2030 (including national grid, mini-grid and stand-alone systems) is **680 MUSD in the conservative scenario as compared to 880 and 1000 in the other two scenarios**, which is an important difference. However, though all villages are electrified in all three cases, only 50% instead of 70% HH are covered by grid equivalent supply in the conservative scenario.

The **requirements for grid investment reduce from 890MUSD to 420MUSD** in which the requirement for MV investments reduces from 344MUSD to 143MUSD, thus bringing the responsibilities of EDC in terms of MV back bone financing and construction to very manageable levels. But the challenge remains for the distribution side, to be undertaken mostly by the private sector.



For the first 5 years regarding the grid requirements, the conservative scenario staggers grid investments to a very manageable **123MUSD** (50MUSD for MV), down from an ambitious **327 MUSD** (143 for MV) in the baseline scenario and from **200MUSD** (84 for MV) in the intermediate scenario

However, in order to still reach the village and household coverage targets, the consequence is that globally mini-grid and stand-alone investment requirements rise tremendously:

- In the **baseline** scenario to 2030, **76MUSD** are required for mini grids and **40MUSD** for stand alone options;
- In the **intermediate** scenario, these figures increase to **102MUSD** and **96MUSD**;
- They reach **124MUSD** and **130MUSD** for the **conservative** scenario.

	Baseline			Intermediate			Conservative		
Mini-grid projects in rural areas by 2015	Number of projects	Total Installed capacity (MW)	Inv. costs (MUSD)	Number of projects	Total Installed capacity (MW)	Inv. costs (MUSD)	Number of projects	Total Installed capacity (MW)	Inv. costs (MUSD)
Hydro mini-grid	33	6.4	32.6	35	6.6	36.2	38	7.3	40.0
Biomass mini-grid	25	10.3	17.1	38	13.8	21.2	49	16.2	24.5
New diesel mini-grid	150	21.7	26.7	233	34.7	44.2	289	46.8	59.4
Total	**208**	**38.4**	**76.4**	**306**	**55.2**	**101.6**	**376**	**70.3**	**123.9**

	Baseline		Intermediate		Conservative	
Stand-alone systems in rural areas by 2020	Number	Inv. costs (MUSD)	Number	Inv. costs (MUSD)	Number	Inv. costs (MUSD)
Solar home systems (new kits)	37 423	15.0	80 936	32.4	114 413	45.8
Community PV (new villages)	1 994	4.4	5 078	9.6	6 475	12.6
Solar battery charging stations (new villages)	1 024	20.9	2 943	54.1	3 564	71.8
Total	**N/A**	**40.3**	**N/A**	**96.0**	**N/A**	**130.1**

In case the proposed new diesel projects are hybridised with PV, the additional costs range between **21** to **45 MUSD** as shown below:

Capacity range (kW)	Proposed solution	Baseline			Intermediate			Conservative		
		Number of projects	PV installed capacity (kWp)	Inv. costs (MUSD)	Number of projects	PV installed capacity (kWp)	Investment cost (MUSD)	Number of projects	PV installed capacity (kWp)	Inv. costs (MUSD)
<30	100% storage	7	37	0.2	9	40	0.3	10	46	0.3
30-100	50% storage	43	523	2.9	67	780	4.4	77	928	5.2
>100	0% storage	100	3 773	17.8	160	6 120	28.9	205	8 392	39.7
	Total	**150**	**4 333**	**21.0**	**236**	**6 940**	**33.6**	**292**	**9 366**	**45.2**

These figures show the depth of the potential off grid market and of private sector investment, as for the time being, there is no public financing of off grid options envisaged. However, for the private sector to mobilise on this segment, a tremendous amount of work still is required by way of developing the legal framework, business and financing models. In order to meet short targets for 2015, it is already doubtful in any of the three scenarios that the required financing for mini grid and stand alone options could be mobilised:

- **72MUSD** for mini grids and **19MUSD** for stand alone systems are needed for the first 5 years in the **baseline** scenario
- **91MUSD** and **46MUSD** in the **intermediate** scenario
- Culminating to **109MUSD** for mini-grids and **62MUSD** for stand alone systems in the **conservative** scenario

Hence, by no means is the conservative scenario “conservative” with regards to fund mobilisation from the private sector, or more broadly for off grid solutions bearing in mind the mobilisation to date is albeit marginal. And again, the proximity of proposed projects with the existing and planned national grid must be stressed as a potentially very challenging issue, if it is not addressed properly by the regulatory framework as suggested below.

G- Policy recommendations

Though the present report is definitely not a policy or regulatory study, it clearly highlights that the policy targets of the Cambodian government will be impossible to reach with an appropriate and conducive regulatory framework, covering at least the following areas:

- Streamlining issues of interface between private operators (REEs) and EDC regarding:
    - Distribution
        - Working with current and future isolated REEs on technical standards, in order to anticipate their future interconnection with the national grid;
        - Harmonising the price of bulk sale from EDC to the distribution licensee and the tariff at which the distributor then sells to the end users, possibly using cross-subsidies (will become possible once power systems interconnection is achieved nation-wide);
    - Generation, terms and conditions of sale of power to the national grid should be clearly defined, in order to foster private investment:
        - Regulated feed-in tariffs (FITs) should be set for renewable energy technologies, allowing sufficient profitability for project developers, while still remaining on par with current production costs on the national grid;
        - Adequate administrative mechanisms should make Power Purchase Agreements (PPA) easier to obtain, especially for small-scale projects;
- Regulations should cover health, safety and environmental aspects of captive power generation for own use (from biomass in particular), as well as conditions of sale of possible excess power to a power distributor (cf. above);
- Specific attention should be paid to taxation and duties issues, to ensure that such innovative projects are not unduly burdened, especially during the first years;
- Long term financing mechanisms will have to be put in place, which is not the practice of local commercial banks – and the REF is not yet in these activities. Soft loans, long term, with appropriate grace periods are an absolute requirement;
- Appropriate facilitation, in terms of capacity building, project identification and development is also a need;
- Finally, the load forecast has been done making the assumption that the average household demand is 34.1kWh /month, with an average bill of 6.4USD/month. Though on average today, households may be able to afford this, it is only an average, and further, going into remoter areas of Cambodia, affordability will be lower: clearly, a national tariff policy (e.g. cross-subsidies) will have to be thought through, if the current very ambitious household connection targets are to be met.

H- Planning methodology and tools

The planning approach used in the SREP project is based on the GEOSIM aid decision tool, based on a Geographical Information System (GIS). The very novel feature of this approach is that it gives priority status to villages defined as “Development Poles” : the villages have been given a score (Indicator for Potential Development - IPD) according to a set of criteria combining health, education and income generation aspects. Then the villages with the highest IPD, i.e. the ones concentrating school, health and economic services, have been selected and chosen as priorities for electrification in order the maximise the potential impact of electrification on the surrounding areas, as well as guarantee a higher profitability for the project developer.

This approach requires the establishment of a very detailed and comprehensive GIS database, covering the grid network (existing and planned), renewable energy potential, infrastructure (roads, bridges) as well as socio-economic aspects (socio-economic characteristics and location of villages). This data collection has been conducted both at the national level directly from the relevant ministries and agencies (MIME, EDC, EAC, Ministry of Health, Ministry of Education, Ministry of Planning, Ministry of Public Works and Transport…), and at the provincial level (mostly from the PDIME). All available data has been collected and processed, and supplemented with an extensive survey carried out by provincial authorities (PDIME) in more than 150 industries, in order to assess the potential for agro-industry based biomass projects and determine the possible demand of medium-scale rural power consumers. As a result, an extensive GIS database of about 20,000 rural businesses and industries has been established. Identification of potential projects for mini-hydro, biomass and diesel projects has been carried out through desk studies and field visits.

Because of uncertainties on forecast assumptions and rapid changes in the situation of the country (for example in the agro-industry sector or grid extension planning), every planning exercise needs to be updated regularly. That is why the project went beyond the mere production of a Master Plan document, and strived to transfer the GEOSIM planning tool to MIME. MIME indeed played a key role in all activities, covering data collection and production of plans, and is currently training provincial authorities (PDIME) of 6 provinces on the utilisation of this tool. A total of 8 computers and 12 software licences have been provided as part of project activities.

Finally, to better illustrate the transition from the planning exercise to project implementation, feasibility studies are carried out on a few interesting projects identified at planning stage, and possible investors and financing schemes are being sought.